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Long-term count data demonstrate the regional significance of Bako-Buntal Bay, Malaysian Borneo, for wintering shorebird conservation

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Bako-Buntal Bay in Sarawak, Malaysia is among the most important coastal wetlands for migratory shorebirds in Borneo, and in insular Southeast Asia. However, since the multi-year waterbird surveys of the Sarawak coast during 2010–2012, there has been little published work on migratory shorebirds here. Our study assessed the status and populations of migratory waterbirds utilizing two sites within Bako-Buntal Bay: (1) the extensive mud and sand flats of Buntal Bay used as a neap tide roost site, and (2) the man-made (ash) ponds at Sejingkat regularly used as spring tide roost sites. We counted waterbirds twice a month from October 2018 to March 2019, and compiled monitoring data from the Asian Waterbird Census and other surveys starting in either 2006 or 2007. We found a total of 32 waterbird species in Buntal and 31 species in Sejingkat, including globally significant numbers of four threatened species: Far Eastern Curlew *Numenius madagascariensis* (EN), Great Knot *Calidris tenuirostris* (EN), Nordmann's Greenshank *Tringa guttifer* (EN), and Chinese Egret *Egretta eulophotes* (VU). Our study showed that the total counts of waterbirds at Buntal, and especially Sejingkat, have increased consistently from 2006–2007 to 2019, particularly with an increasing trend for Far Eastern Curlew and a sudden increase in Great Knot numbers in 2019. Using flag resightings, we established connections between our study sites and sites along the East Asian-Australasian Flyway, e.g. Chongming Island in Shanghai, China and Kamchatka in Russia. We are unsure of the factors driving the increase of shorebird numbers, but hypothesize a possible decline in habitat extent and quality elsewhere on Borneo or in the wider Southeast Asian region. Our work demonstrates the continued importance of Bako-Buntal Bay for shorebirds, especially the Far Eastern Curlew, in Southeast Asia, and the need for sustained conservation measures.

Keywords

artificial wetlands

East Asian-Australasian Flyway

Far Eastern Curlew

Great Knot

migratory birds

mud and sand flats

Sarawak

Southeast Asia

INTRODUCTION

Of the world's nine major migratory flyways, the East Asian-Australasian Flyway (EAAF), which spans 22 countries, supports more migratory species than any other flyway, and is considered to be the most threatened of the world's flyways (Conklin *et al*. 2014, Yong *et al*. 2018). The Southeast Asian island of Borneo is a stopover and staging area for migrating birds between northern Asia, Southeast Asia and Australasia (McClure 1974, Bamford *et al*. 2008, Mann 2008, Lim *et al*. 2020). There is a relatively well-established body of citizen science data on bird migration in Borneo, and several coastal sites, such as Kuala Baram and Pulau (= island) Bruit, are well known for wintering shorebirds (e.g. Simpson 1983, Mann 2008). Moreover, recent satellite tracking of shorebirds has provided novel evidence for how wetland sites along the coastline of Borneo (e.g. in the Malaysian states of Sabah and Sarawak, and Indonesia's Kalimantan) are used by shorebird species such as Great Knot *Calidris tenuirostris*, Red Knot *C. canutus* and Sanderling *C. alba* as stopover or staging sites (van Eerbeek 2013, Lisovski *et al*. 2016, Chan *et al*. 2019a).

The 1,035 km coastline of Sarawak (Malaysian Borneo) provides important wintering and staging grounds for

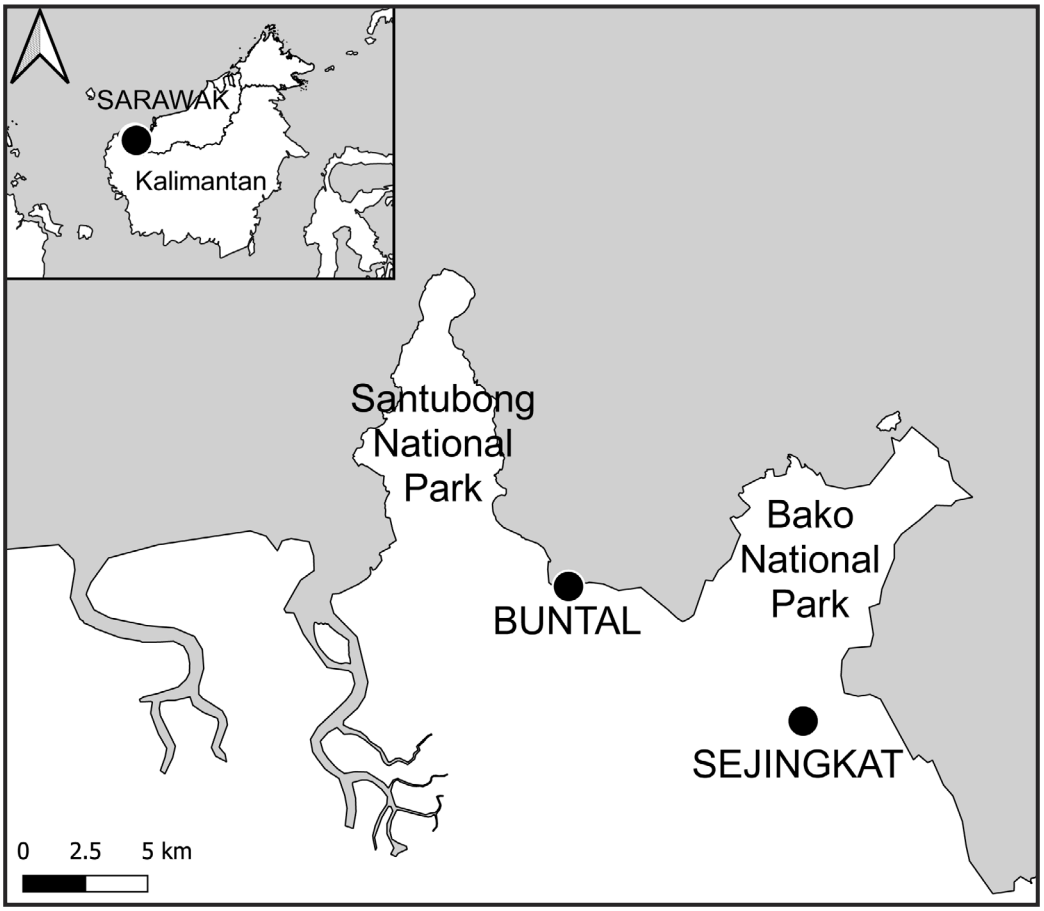

Fig. 1. Survey sites within the Bako-Buntal Bay Important Bird and Biodiversity Area (IBA) in Sarawak, Malaysian Borneo.

more than 30 migratory waterbird species (Parish 1987, Orenstein *et al.* 2010, Bakewell *et al.* 2017). It has a diversity of coastal environments, ranging from rocky shores, intertidal flats and sandy beaches, to large areas of mangrove forests (Shabdin 2014), including some of the most important areas of coastal wetlands within both Malaysia and Southeast Asia, such as the Baram Estuary and Bako-Buntal Bay (Li *et al.* 2006, Yeap *et al.* 2007, MacKinnon *et al.* 2012, Bakewell *et al.* 2017, BirdLife International 2020, Mehlman *et al.* 2020). In particular, the extensive intertidal flats spanning the coastline of Bako-Buntal Bay in southwest Sarawak (Fig. 1) are among the most important sites for staging and over-wintering waterbirds on Borneo, supporting not only high shorebird diversity, but also globally significant congregations of threatened species such as Great Knot, Nordmann's Greenshank *Tringa guttifer*, Far Eastern Curlew *Numenius madagascariensis* and Chinese Egret *Egretta eulophotes* (Yeap *et al.* 2007, Mann 2008, Bakewell *et al.* 2017). In 2016, Bako-Buntal Bay was nominated as Malaysia's first flyway site (EAAF112) under the East Asian-Australasian Flyway Partnership (EAAFP), giving it international recognition. It is also one of 55 Important Bird and Biodiversity Areas (IBAs) in Malaysia (Chan *et al.* 2004, Yeap *et al.* 2007). However, despite its widely recognised conservation value, Bako-Buntal Bay remains essentially legally unprotected.

Although Bako-Buntal Bay is one of the best surveyed coastal wetlands for shorebirds in Borneo, to date there has been surprisingly little effort to assess the trends of wintering shorebirds, or within-season variations in shorebird abundance. Our study aimed to (1) determine whether waterbird populations are using the Bako-Buntal Bay as staging or wintering grounds, by estimating the monthly variation in abundance and diversity of migratory waterbirds, based on counts from October 2018 to March 2019, and (2) determine long-term trends in the overall numbers of waterbirds and of several important species based on long-term data compiled from citizen counts from 2006 to 2019.

METHODS

Site information

We studied waterbird trends at two sites within Bako-Buntal Bay (Fig. 1), an IBA of 3,590 ha (Bakewell *et al.* 2017, BirdLife International 2020). The coastline of Buntal Bay (Teluk Buntal) stretches from a mountainous promontory in the west to a densely forested cape protected within the Bako National Park in the east (Yeap *et al.* 2007, Sarawak Forestry Corporation 2017). Our two study sites within the Bako-Buntal Bay IBA are Buntal Bay (hereafter Buntal) and the Sejingkat ash ponds (hereafter Sejingkat) (Fig. 1).

Buntal (1°41'45.6"N, 110°23'4.1"E) forms an integral part of the wider Bako-Buntal Bay IBA and has large areas of intertidal flats and sandbars that on neaps stay exposed during high tides. Sejingkat (1°38'31.6"N, 110°27'56.2"E) is part of the Sejingkat Coal Power Plant where a number of large, man-made ponds are routinely filled with ash waste from the plant. Both sites are important for migratory shorebirds as high-tide roosts (e.g. Jackson *et al*. 2020) while the intertidal flats at Buntal are also significant feeding areas at low tide. We compiled waterbird count data from three sources: our twice-monthly surveys from October 2018 to March 2019, yearly surveys of the Asian Waterbird Census (AWC) (2006–2019) and surveys by Waterbird Survey of the Sarawak Coast (WSSC) in 2010–2012.

Survey methodology

Twice-monthly surveys – Buntal and Sejingkat were both surveyed twice each month, for six months from October 2018 to March 2019. Most surveys at both sites were undertaken when shorebirds were at high-tide roosts (tide data from the Pulau Lakei tide station). Counts at Buntal were conducted during neap tides (<4.5 m) as birds fly to Sejingkat to roost if the tide is too high, whereas the counts at Sejingkat were carried out on spring tides (>5.0 m). All waterbird species were identified and counted using telescopes (20–60 × 88 mm) and binoculars (10 × 40 mm). At Buntal, we used a small, powered boat to reach an important part of the sand bar at least two hours before high tide. When we reached the sand bar, we carefully scanned the area before moving towards the first group of birds, taking care not to alarm shorebird flocks. Once we had counted a flock, we moved to the next until we reached the far end of the sand bar. At Sejingkat, we arrived at the ash ponds at least an hour before the high tide on the highest spring tide and waited along the bund either using a hide or in a concealed area to minimize alarming the arriving flocks. The birds were counted once they had settled in the pond.

Birds were counted individually if possible, but large flocks and birds in flight were estimated in multiples of 50 or 100. Count results were tabulated as the total number of species observed, per site, per survey day. As previous work had not accounted for birds that may have been present both at Buntal on a neap tide and Sejingkat on a spring tide, we took our counts to be independent, although it is highly likely that there will be some overlap. Therefore the counts for the two sites were not added together. We identified the birds using the relevant field guides (Phillipps & Phillipps 2014, Lee *et al*. 2018) and all counts were conducted by a team consisting of at least two experienced observers. We recorded potential threats to shorebirds during the surveys.

Asian Waterbird Census – In Sarawak, monitoring work and surveys on waterbirds have been carried out since the 1980s (Howes & NPWO 1986a,b) and interest in waterbird conservation has increased since then, although there are few peer-reviewed studies (Edwards & Polshek 1987, Parish 1987, Mizutani *et al.* 2006). The AWC, which forms a part of the International Waterbird Census (IWC) has been conducted annually in Asia since 1987 (Wetlands International 2007). In Sarawak, the AWC counts have been carried out nearly annually by citizen scientists from the Malaysian Nature Society (from its chapters in Kuching and Miri, a leading conservation non-government organisation in Malaysia). The AWC counts provide an important source of time-series data for shorebirds at various wetland sites across Sarawak. We extracted and compiled AWC data for Buntal and Sejingkat, compared them to our survey data, and analysed the trends. Data were available for 2006–2009 (from 2007 at Sejingkat) and 2017–2019 for both sites. Waterbird counts under the AWC surveys are typically land-based and on foot, using telescopes and binoculars, and were very similar to our methodology.

Waterbird Survey of the Sarawak Coast (WSSC) – Surveys were conducted from 6 October 2010 to 9 April 2011, and 28 October 2011 to 21 February 2012, during or near high tide. The total number of individuals for each sector was the sum of the maximum single-day counts for each species. WSSC data were collected using three different approaches, depending on the level of accessibility of the sites: land-based surveys, boat-based surveys, and aerial surveys (by helicopter) for the most inaccessible sites. We extracted data for Buntal and Sejingkat from two sectors defined under the WSSC surveys (i.e. 5, 7 respectively). At Buntal, boat-based surveys were conducted on 19 January 2011, both land and boat-based surveys were conducted on 20 January and 27 October 2011, and an aerial survey on 26 January 2011. At Sejingkat, there were five land-based surveys (23 Jan, 18, 20 & 21 Feb, 27 Oct 2011), and one aerial survey on 26 October 2011.

Land-based surveys were carried out in either a four-wheel-drive vehicle or on foot. Observations were conducted using binoculars (10 × 40mm), telescopes (20–60 × 88 mm) and a digital camera (300 mm). Each survey involved at least two surveyors, a counter and a scribe. Boat-based surveys were conducted with binoculars or, wherever possible, counters would access the shoreline to count. Aerial surveys were conducted if shorebird roosts were inaccessible from land and sea, using a Bell-206 four-seat helicopter with three hours of endurance time. Three surveyors would typically take part: a navigator, a recorder and a photographer. Photographs of flocks were consistently taken to estimate species abundances and identify species in flocks whenever necessary. Specific details of all surveys under the WSSC are available in Bakewell *et al.* (2017).

Analysis of count trends

We assessed trends in populations for all threatened species (Far Eastern Curlew, Great Knot, Nordmann's Greenshank and Chinese Egret) using the maximum count from our surveys and those from the AWC and WCCS datasets. The datasets for these four species were analysed according to the years of available data ranging

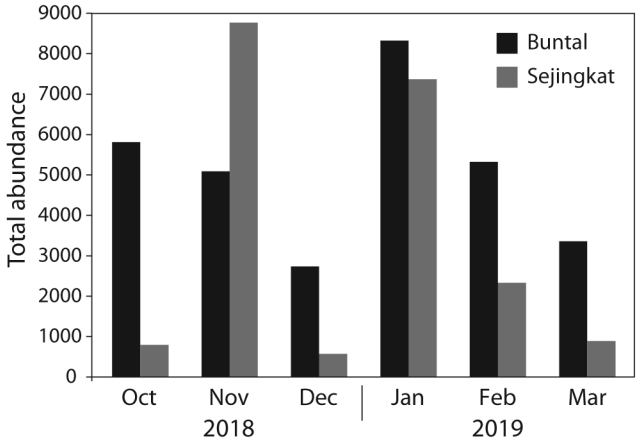

Fig. 2. Total waterbird abundance per month Oct 2018–Mar 2019 in the Buntal Bay (black) and Sejingkat (gray) count sites within the Bako-Buntal Bay Important Bird and Biodiversity Area in Sarawak, Malaysian Borneo. Total abundance is based on single-day maximum counts.

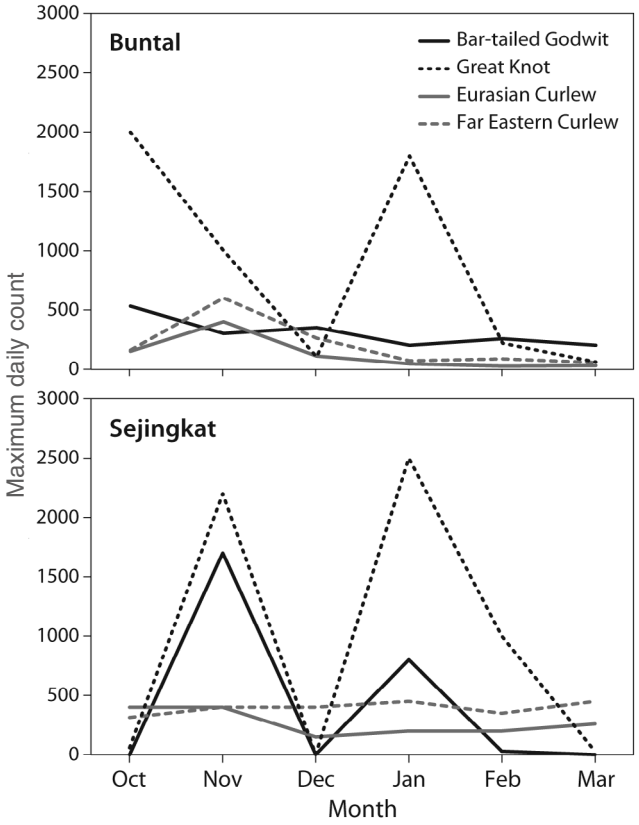

Fig. 3. Maximum daily counts for four key shorebird species, Great Knot, Eurasian Curlew, Far Eastern Curlew, and Bar-tailed Godwit in Buntal Bay (upper panel) and Sejingkat (lower panel), throughout the six months of our study (Oct 2018–Mar 2019).

from 2005–2019. The data were compiled using Microsoft Excel, analysed using simple linear regression models in R (R Core Team 2020) and the trend lines and 95% confidence intervals were plotted using ggplot2 (Wickham 2016). A map of our study site was created using the Free and Open source QGIS (QGIS 2020).

RESULTS

Counts and seasonal trends in 2018–2019

In our 2018 and 2019 surveys, we recorded a total of 32 waterbird species in Buntal, and 31 in Sejingkat (Table S1) and observed large variation in high counts between the two sites and between species (Table S2). Our highest single-day counts for waterbirds was 8,374 at Buntal (16 Jan 2019) and 8,785 at Sejingkat (24 Nov 2018) (Fig. 2, Tables S3 & S4). At both sites, the lowest total count of roosting birds throughout this survey was in December 2018 (2,647 at Buntal and 545 at Seijingkat).

Great Knot was the most numerous shorebird at both sites, with maximum counts of 2,000 individuals in Buntal and 2,500 in Sejingkat (Table 1, Fig. 3). The next most abundant species in Buntal were Greater Sand Plover *Charadrius leschenaultii* (maximum: 2,000) and Lesser Sand Plover *Ch. mongolus* (maximum: 1,800) (Table S2). The next most abundant species in Sejingkat were Bar-tailed Godwit *Limosa lapponica* (maximum: 1,700) and Black-tailed Godwit *L. limosa* (maximum: 1,500).

We found large month-to-month variation in numbers at both Buntal and Sejingkat in Bar-tailed Godwits and Great Knots, but less so in the two curlew species (Fig. 3). Daily maximum counts of Great Knot at Buntal peaked in October 2018, and progressively declined to December, before reaching a second peak of over 1,800 individuals on 16 January (Fig. 3). Bar-tailed Godwits at Buntal were relatively stable. There was a similar pattern at Sejingkat for both Bar-tailed Godwits and Great Knots, with peak counts in November and January. Counts of Far Eastern Curlew at Buntal peaked at 600 individuals in November before gradually declining. By contrast, counts of Far Eastern Curlew remained consistent at Sejingkat (250–450 individuals). Eurasian Curlew show similar levels but slightly lower peak numbers of 400 individuals.

Of the globally threatened species, at Buntal we had a maximum count on a single day of 600 Far Eastern Curlew (EN), 2,000 Great Knot (EN), seven Nordmann's Greenshank (EN), and 40 Chinese Egret (VU). While at Sejingkat the figures were 450 Far Eastern Curlews (EN), 2,500 Great Knot (EN) and four Nordmann's Greenshank (EN).

Yearly trends in non-breeding waders

In the January 2011 survey of the Sarawak coast conducted by WSSC, a total of 8,616 individuals of 27 species was counted at Buntal, and 1,447 individuals of 17 species at Sejingkat (Bakewell *et al.* 2017) (Fig. 4).

The total waterbird count by AWC at Buntal appeared relatively stable from 2006 (4,212 individuals) to 2019 (5,969), with a peak of 9,335 birds in 2017 (Fig. 4). At

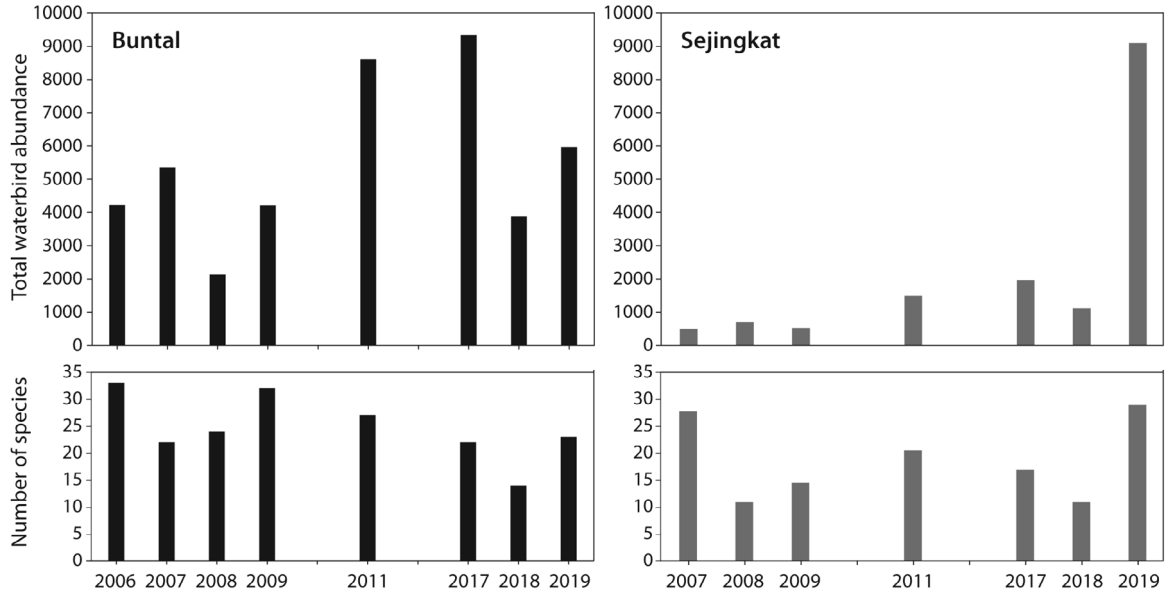

Fig. 4. Upper panels: total waterbird abundance during the non-breeding season in Buntal Bay (2006–2019; left panels) and in Sejingkat (2007–2019; right panels). Lower panels: total number of waterbird species at both sites. Data from 2011 are extracted from WSSC and the other years from AWC. NB: No surveys were conducted in 2010 and 2012. Counts conducted in Dec/Jan are indicated by their terminal year, e.g. 2019 includes counts in Dec 2018 covering the boreal winter of 2018–2019.

Sejingkat, the total AWC count increased from 2007 to 2019 from 484 to 7,358 individuals (Fig. 4); the sudden large increase in 2019 was partly driven by an increase in Great Knots, with 1,752 individuals using the site in 2019. Using the same dataset, we compiled the total species numbers from 2007–2009, 2011 and 2017–2019 (Fig. 4). At both sites, the number of species observed fluctuated from year to year (Buntal: 14–33; Sejingkat: 8–24). However, the total number of species throughout our study in 2018–2019 in Sejingkat was considerably higher (31) although it was quite similar for Buntal (32).

Of the globally threatened species, counts of Far Eastern Curlew over time have shown a large and highly significant increase in Sejingkat (R^2 = 0.88, P = 0.001; Fig. 5b) but not at Buntal (Fig. 5a). No significant trends were detected for Great Knot, Nordmann's Greenshank (Fig. 5c–f) or Chinese Egret (not shown) (all $P > 0.05$).

Leg flag resightings

Flagged individuals of five species were found, with a total of 17 sightings of an unknown number of individuals (see Table S5 for more details). Most of the sightings involved birds banded on Chongming Island, Shanghai, China on the Yellow Sea coast (n = 10) and Kamchatka, Russia (n = 4). Leg-flagged Great Knots were from Chongming Island (n = 3), Kamchatka (n = 3), and northern Japan (n = 1). All Far Eastern Curlew and Nordmann's Greenshank were from Chongming Island (n = 3 and 2) . Red-necked Stints *Calidris ruficollis* were mostly from Chongming Island (n = 3), and also from Java or Bali,

Table 1. The importance of Buntal and Sejingkat (Bako-Buntal Bay, Sarawak, Malaysian Borneo) for globally threatened waterbird species, based on the 1% flyway criteria, where the Threshold refers to the number representing 1% the total flyway population (based on Wetlands International 2021). Highest count refers to highest count on a single day between 2006–2007 and 2019. Counts exceeding the 1% Threshold are in bold.

Common name	Scientific name	IUCN Conservation Status	Highest count in Buntal	Highest count in Sejingkat	1% Threshold
Far Eastern Curlew	*Numenius madagascariensis*	EN	**600**	**450**	320
Great Knot	*Calidris tenuirostris*	EN	2,000	2,500	2,900
Nordmann's Greenshank	*Tringa guttifer*	EN	**7**	4	5
Chinese Egret	*Egretta eulophotes*	VU	**40**	N/A	35

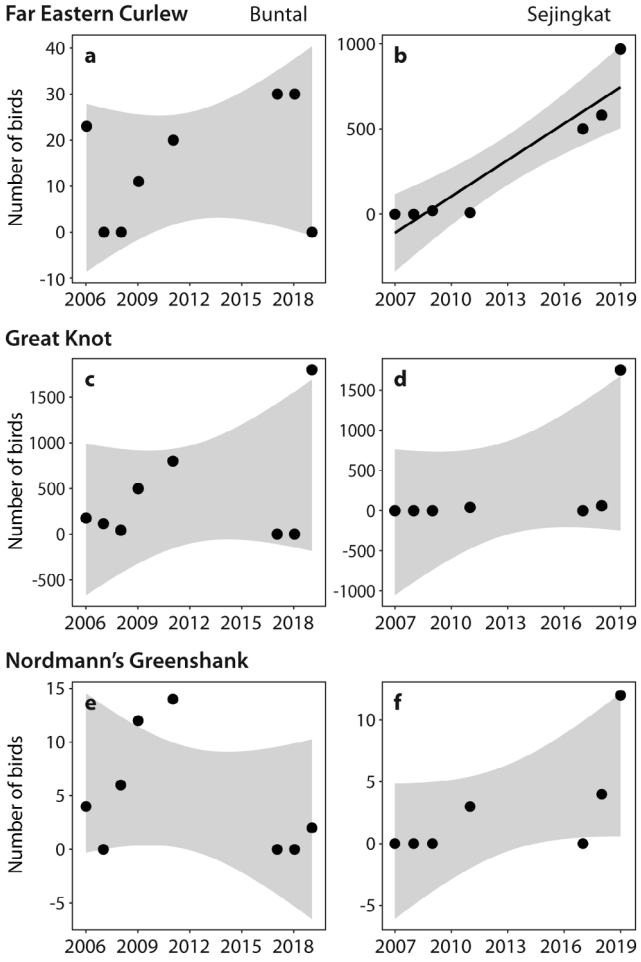

Fig. 5. Population trends of Far Eastern Curlew, Great Knot and Nordmann's Greenshank during the non-breeding season in Buntal Bay (2006–2019; left panels) and in Sejingkat (2007–2019; right panels), based on AWC and WCSS data from 2005–2006 or 2006–2007 to 2019.

Indonesia (n = 1) and Kamchatka, Russia (n = 1). The single Red Knot was banded on the North Island of New Zealand.

DISCUSSION

Important roosting sites and significance for EAAF shorebirds

Our surveys show that both Buntal and the adjacent ash ponds at the Sejingkat power station are globally important staging and wintering sites for migratory waterbirds, and continue to sustain significant populations of four globally threatened migratory waterbirds. Both are considered as among the most important areas for shorebirds on the Sarawak coast (Yeap *et al.* 2007, Bakewell *et al.* 2017, Lim *et al.* 2020), and potentially in all of Malaysian Borneo. Note that there are large gaps in knowledge of shorebird distributions on the Indonesian Borneo coastline, which potentially contains unknown important areas for shorebirds.

Based on past surveys and citizen science observations, the intertidal flats of Buntal are an important wintering site for several threatened species such as Chinese Egret and Far Eastern Curlew (Mann 2008, Phillipps & Phillipps 2014). Our study shows that the wetlands of Buntal harbour more than 1% of the EAAF population of the Chinese Egret (*ca.* 1.14%) and Nordmann's Greenshank (*ca.* 1.40%) in mid-winter. Both sites also hold over 1% of the EAAF populations for passage or wintering Far Eastern Curlew (*ca.* 1.88% in Buntal, 1.41% in Sejingkat). From November to December 2018, our monthly surveys at both sites showed a decrease in overall shorebird numbers, with a rapid increase in January 2019. This increase may be due to localised dispersal of wintering bird species along the wider Sarawak coastline, such as Greater Sand Plovers *Charadrius leschenaultii* and Grey Plovers *Pluvialis squatarola*. From our surveys, counts of Great Knot peaked in October (Buntal) and November (Sejingkat) (Fig. 3). The number then drastically decreased before reaching another peak around January, and continue to decline until the end of the migration period. This suggest that the birds are roosting at different areas during the winter. A different case can be seen for Far Eastern Curlew where their numbers in both sites seem to appear quite stable throughout the entire non-breeding period.

Species of conservation concern: comparison with previous surveys

Four species of waterbirds of conservation concern occurred in globally significant numbers at our study sites – Chinese Egret (VU), Far Eastern Curlew (EN), Nordmann's Greenshank (EN) and Great Knot (EN) – and will need to be regularly monitored in the longer term. Our data suggest that the maximum wintering Chinese Egret population in Buntal is around 40 and may have slightly declined over time (not shown) and this may potentially reflect wider patterns of population change. Given the global significance of Buntal for the species (>1% of the EAAF population; see Table 1, also Orenstein *et al.* 2010, Bakewell *et al.* 2017) as one of few monitored wetlands important to the species within its Southeast Asian wintering range, there is a need to better study the species' ecology not only on the Borneo coast, but more widely across the flyway to determine regional trends.

We used unpublished and published AWC and WSSC data (e.g. Bakewell *et al.* 2017) to determine overall trends in waterbird abundance, and individual trends for Far Eastern Curlew, Great Knot and Nordmann's Greenshank. Our comparisons show that the total number of waterbird species fluctuated at both sites, although there was a substantial increase in numbers at both sites in 2019, particularly among Far Eastern Curlew and Great Knot (Fig. 5). The total count of Far Eastern Curlew in Sejingkat nearly doubled from 581 to 970 individuals from 2018 to 2019. The total count of Great Knot in Buntal was 800 individuals in 2011, but this has since more than doubled to a maximum count of *ca.* 1,800 individuals in 2019. Note that in January 2019 our survey and AWC found a similar number of individuals, but both counts were

lower than during our survey in October 2018 where we counted a maximum of *ca.* 2,000 Great Knots. At Sejingkat, the Great Knot count was only 80 individuals in 2011 but the maximum count in 2019 was *ca*. 1,752 individuals.

The large increases in counts of these two threatened shorebirds are unusual, given that global populations of both Great Knot and Far Eastern Curlew are in decline (Conklin *et al*. 2014, BirdLife International 2020) and are unlikely to have arisen from differences in observer skill and effort alone. There are three possible explanations: (1) as yet undetected habitat loss along the Sarawak coastline, or degradation of the quality of mud and sand flats habitat may have forced staging or wintering birds to relocate to Buntal and Sejingkat; (2) populations wintering elsewhere in the region (e.g. Australia) may have adjusted and shortened their migrations, and are now wintering in Borneo, driving up localized abundances of wintering birds as has been reported elsewhere in Southeast Asia (e.g. Round & Bakewell 2015); (3) since the sites were surveyed during different tidal phases, the differences in numbers may arise due to the congregation of different groups of Great Knot foraging at sites along the coastline north of the bay to the Sungai (= river) Batang Lupar, and were thus unaccounted for by the Buntal surveys. Further satellite tagging work (e.g. Chan *et al.* 2019a) may help to resolve these knowledge gaps, and the movement of different flocks potentially driving these observed variations.

Other important sightings and records

During our surveys, we observed two Black-headed Gulls *Chroicocephalus ridibundus* at Sejingkat in January 2019, and a single Lesser Crested Tern *Thalasseus bengalensis* at Buntal in March 2019. Both species are of Least Concern (LC) but are considered as rare species with very few records from the Sarawak or the wider Bornean coastline. Further surveys at both sites can be expected to detect stragglers and other rare shorebirds.

Threats to migratory shorebirds

We found no evidence of hunting at Buntal or Sejingkat during our surveys, unlike many other coastal parts of Southeast Asia where shorebirds hunting is widespread (Gallo-Caijiao *et al*. 2020, Nguyen *et al*. 2020). However, we saw extensive plastic waste pollution along the shoreline with high concentrations at high tide roosts. This may have detrimental effects on coastal wildlife and the mudflat benthos over time as plastic waste would break down into microplastics. Although there is limited information on the effect of microplastics on animals, it has been suggested that plastic pollution could pose a longer-term threat affecting shorebirds if ingested (Rossi *et al*. 2019). The ash ponds in Sejingkat are man-made wetlands, similar to those in Kapar, Peninsular Malaysia (see Li *et al.* 2006, Jackson *et al*. 2020) and were created for dumping ash residues from a coal fired power station. Once the ponds have been fully filled in, new ponds are usually dug. Noise pollution from the power station and ash dumping operations may disturb the roost, and there may also be negative effects of chemical pollutants leached from ash. However, the habitat may be lost in the future if the power station stops operating, as local power generators are turning to renewable energy.

Flyway connections

Our surveys found several shorebirds, including three threatened species (e.g. Great Knot, Far Eastern Curlew, Nordmann's Greenshank) that were leg-flagged on Chongming Island on the Yellow Sea coast of China, demonstrating the migratory linkages between shorebird populations staging in the Yellow Sea, and those overwintering in Borneo. Furthermore, the staging site in Kamchatka, Russia was represented by three of seven resightings of Great Knots and one in four Red-necked Stints, confirming the role of this staging site in the flyway (Dorofeev & Kazansky 2013). Recent studies such as Chan *et al.* (2019a) further demonstrate the migratory routes of satellite-tagged Great Knot linking Borneo and the Yellow Sea coast of China, the Koreas and Kamchatka. The coastal wetlands along the Yellow Sea form important refuelling stops for shorebirds on the EAAF (Barter 2002), and thus declines in the condition of coastal wetlands there will have far reaching, knock-on effects on shorebird populations throughout the flyway, including populations staging or wintering on Borneo's coastline and elsewhere in Southeast Asia. Large areas of wetlands on the Yellow Sea coastline have already been lost due to coastal development (Murray *et al*. 2014) and there is strong evidence now that the higher the reliance of shorebirds on these wetlands, the steeper they decline (Studds *et al*. 2017). Although there have been new developments from governments to limit coastal land reclamation (e.g. BirdLife International 2018), coastal areas of the Yellow Sea face heavy development pressure which has resulted in substantial habitat loss (Murray *et al.* 2014, Chen *et al.* 2019, Duan *et al.* 2020); this could affect the shorebird populations connecting these areas and the Bornean coastline, including wetlands in Bako-Buntal Bay.

Recommendations for future work

Borneo forms one of the least known parts of the EAAF for migratory shorebirds, and is only beginning to become better studied through satellite tracking and ground-based surveys such as ours. Our study summarised new (from our field work) and unpublished data on shorebird assemblages and their abundance trends over time at Bako-Buntal Bay, arguably Borneo's best known site for shorebirds, and confirms that it remains a significant wetland for shorebird conservation, especially for Far Eastern Curlew. Our leg-flag observations and recent studies (e.g. Chan *et al.* 2019a) demonstrate the connections between shorebird populations migrating between the Borneo coastline and the Yellow Sea. Moving forward, strengthened legal protection of this coastline should be a priority of the Sarawak State government alongside monitoring. Further surveys should aim to determine other potentially important sites as roosts and foraging areas for shorebirds in Bako-Buntal Bay, as well as the extensive

mud and sand flats-dominated coastline in southwest Sarawak. Coordinated counts starting from the arrival of the birds to their departure to their breeding grounds, and tagging studies (e.g. Chan *et al.* 2019a,b), should be conducted in the future to better understand the use of different sites by shorebird populations within the region. Lastly, there is a need for further engagement with local stakeholders, including the management of Sejingkat Power Station to establish long-term plans to manage these man-made wetlands, while potentially forging collaborative relationships (e.g. sister-site twinning) with international stakeholders to build capacity for migratory species conservation (Mehlman *et al.* 2020).

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ONLINE SUPPLEMENTARY INFORMATION

Table S1. All species recorded during our field surveys of Buntal and Sejingkat, in Bako-Buntal Bay, Sarawak, Malaysian Borneo.

Table S2. Highest count for each species found in each site (Buntal or Sejingkat) in Bako-Buntal Bay, Sarawak, Malaysian Borneo.

Table S3. Total count for waterbirds in Buntal in Bako-Buntal Bay (Sarawak, Malaysian Borneo) throughout the entire survey.

Table S4. Total count for waterbirds in Sejingkat in Bako-Buntal Bay (Sarawak, Malaysian Borneo) throughout the entire survey.

Table S5. List of leg-flagged birds recorded during our surveys of Buntal and Sejingkat, in Bako-Buntal Bay, Sarawak, Malaysian Borneo.

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